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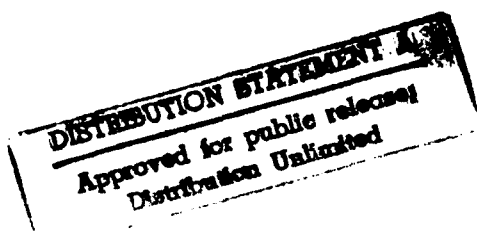


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FINAL REPORT
JANUARY 1991

REPORT NO. EVT 22-90

TRANSPORTABILITY TESTING OF
2,000-POUND BOMBS
IN A SIDE OPENING
COMMERCIAL CONTAINER



Prepared for:
U.S. Army Defense Ammunition
Center and School
ATTN: SMCAC-DET
Savanna, IL 61074-9639

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VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639

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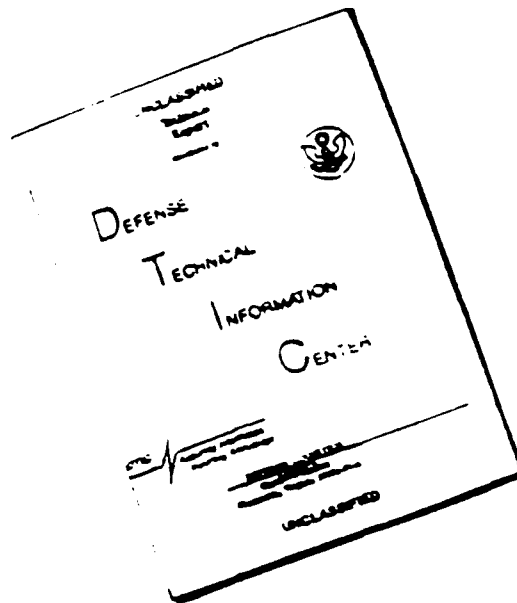
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REPORT DOCUMENTATION PAGE				<i>Form Approved OMB No. 0704-0188</i>	
1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			UNLIMITED		
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) EVT 22-90			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION U.S. Army Defense Ammunition Center and School		6b. OFFICE SYMBOL (if applicable) SMCAC-DEV	7a. NAME OF MONITORING ORGANIZATION		
6c. ADDRESS (City, State, and ZIP Code) ATTN: SMCAC-DEV Savanna, IL 61074-9639			7b. ADDRESS (City, State, and ZIP Code)		
8a. NAME OF FUNDING / SPONSORING ORGANIZATION U.S. Army Defense Ammunition Center and School		8b. OFFICE SYMBOL (if applicable) SMCAC-DET	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code) ATTN: SMCAC-DET Savanna, IL 61074-9639			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.
			WORK UNIT ACCESSION NO.		
11. TITLE (Include Security Classification) Transportability Testing of 2,000-Pound Bombs in a Side Opening Commercial Container					
12. PERSONAL AUTHOR(S) A. C. McIntosh					
13a. TYPE OF REPORT Final		13b. TIME COVERED FROM _____ TO _____		14. DATE OF REPORT (Year, Month, Day) 1990 August	
15. PAGE COUNT					
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP			
19. ABSTRACT (Continue on reverse if necessary and identify by block number) <div style="text-align: justify;"> <p>The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by USADACS, Transportation Engineering Division (SMCAC-DET), to verify the procedure, Loading and Bracing With Wooden Dunnage in Side Opening Commercial Containers of 2,000-Pound Bombs, MK84, and MODs, Unitized, Two Bombs Per Metal Pallet, MK79 MOD O, would meet the transportation requirements of Transportability Testing Procedures, EVT-TP-1-86. The test configuration was subjected to rail, road hazard, road trip, washboard, and shipboard transportation simulation tests. The loading and bracing procedure successfully passed all tests and was approved.</p> </div>					
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED		
22a. NAME OF RESPONSIBLE INDIVIDUAL JEROME H. KROHN			22b. TELEPHONE (Include Area Code) 815-273-8929		22c. OFFICE SYMBOL SMCAC-DEV

U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL

Validation Engineering Division

Savanna, IL 61074-9639

REPORT NO. EVT 90-22

TRANSPORTABILITY TESTING OF 2,000-POUND BOMBS
IN A SIDE OPENING COMMERCIAL CONTAINER

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PART 1

GENERAL

A. INTRODUCTION. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by USADACS, Transportation Engineering Division (SMCAC-DET), to test a loading and bracing procedure for 2,000-pound bombs using wooden dunnage in a side opening commercial container. The test load consisted of inert MK84 bombs, unitized, two to a MK79 MOD O pallet. A total of eight pallets were used to load the side opening container to a gross weight of 40,215 pounds. Transportability tests are in agreement with the procedures outlined in part 4.

B. AUTHORITY. Testing was accomplished in accordance with mission responsibilities delegated by U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL. Reference is made to Change 4, 4 October 1974, to AR-740-1, 23 April 1971, Storage and Supply Operations; and, AMCCOM-R 10-17, 13 January 1986, Mission and Major Functions of USADACS.

C. OBJECTIVE. The objective of these tests is to determine if the proposed loading and bracing procedure using wooden dunnage in side opening commercial containers of 2,000-pound bombs will satisfy road, rail, and ship transportation environments.

D. CONCLUSIONS. The proposed loading and bracing with wooden dunnage in side opening commercial containers of 2,000-pound bombs, MK84, and MODs, unitized, two bombs per metal pallet, MK79 MOD O, passed the rail transportation, road hazard, road, washboard, and shipboard transportation simulation tests.

E. RECOMMENDATIONS. It is recommended that the loading procedure be accepted for the transportation of 2,000-pound bombs in a side opening commercial container.

PART 2

TRANSPORTABILITY TEST OF 2,000-POUND BOMBS
IN A SIDE OPENING COMMERCIAL CONTAINER

AUGUST 1990

TEST ATTENDEES

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U.S. Army Defense Ammunition Center
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ATTN: SMCAC-DET
Savanna, IL 61074-9639

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Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/	
Availability Codes	
Avail and/or	
Dist	Special

A-1

Dan Healy
Senior Inspector
708-392-6846
202-828-1999

Association of American Railroads/
Bureau of Explosives
309 N. Douglas
Arlington Heights, IL 60004

PART 3

TEST PROCEDURES

A. RAIL IMPACT TEST. The commercial side opening container with the inert load of 2,000-pound bombs was positioned on a container chassis and securely locked in place using the twist locks at each corner. The chassis, with the mounted container, was secured to a Trailer-on-flatcar (TOFC) type railcar, equipped with friction draft gear. Equipment needed to accomplish the test included the specimen (hammer) car, five empty railroad cars to serve as the anvil (total weight of the railroad cars is 250,000 pounds), and a railroad locomotive. The anvil cars were positioned on a level section of track with the draft gear compressed, and the air and hand brakes set. The locomotive unit pulled the specimen car several hundred yards away from the anvil cars, then pushed the specimen car toward the anvil at a predetermined speed, disconnected the specimen car approximately 50 yards away from the anvil cars, and allowed the specimen car to roll freely along the track until it struck the anvil. This constituted an impact. Impacting is accomplished at speeds of 4, 6, and 8 miles per hour (mph) in one direction and at a speed of 8 mph in the opposite direction. The 4 mph and 6 mph impact speeds are approximate, the 8 mph speed is a minimum. Impact speeds are determined by using an electronic counter to measure the time required for the specimen car to traverse an 11-foot distance immediately before contact with the anvil cars.

B. ROAD HAZARD COURSE. The commercial side opening container, with the inert load of 2,000-pound bombs, was positioned on a container chassis and securely locked in place using the twist locks at each corner. The chassis was towed over the road hazard course with a tractor twice at a speed of approximately 5 mph. The speed was increased or decreased, as appropriate, to produce the most violent load response.

C. ROAD TRIP TEST. Using a suitable tractor, the chassis with commercial side opening container, inertly loaded with 2,000-pound bombs, was towed a total distance of at least 30 miles over a combination of roads surfaced with gravel, concrete, and asphalt. The test route included curves, corners, railroad crossings, cattle guards, stops, and starts. The test vehicle traveled at the maximum speed suitable for the particular road being traversed, except as limited by legal restrictions. The road test usually concludes with three full airbrake stops while traveling in the forward direction, and one in the reverse direction while traveling down a 7 degree grade. For this test, the panic stops were omitted as the test specimen sustained greater longitudinal shock forces in the rail impact test than would be realized in the panic stops.

D. POST ROAD TRIP HAZARD COURSE. After completion of the road trip test, the chassis with container was towed over the road hazard course with a tractor twice at a speed of approximately 5 mph. The speed was increased or decreased, as appropriate, to produce the most violent load response.

E. WASHBOARD COURSE. The chassis with commercial side opening container, inertly loaded with 2,000-pound bombs, was towed over the washboard course at a speed which produced the most violent response in the particular test load (as indicated by the resonant frequency of the suspension system beneath the load).

F. SHIPBOARD TRANSPORTATION SIMULATION. The commercial side opening container, with the inert load of 2,000-pound bombs, was positioned onto the Shipboard Transportation Simulator (STS) and securely locked into place using the cam lock at each corner. The STS began oscillating at an amplitude of 30 degrees \pm 2 degrees, either side, at a frequency of 2 cycles-per-minute (30 seconds \pm 2 seconds total per roll period). This frequency was maintained for at least 15 minutes during which time the load was observed for apparent defects which could have caused a safety hazard. The frequency of oscillation was then

increased to 4 cycles-per-minute (15 seconds \pm 1 second roll period) and was maintained for two hours. When an inspection of the load did not show any impending failure, the frequency of oscillation was increased to 5 cycles-per-minute (12 seconds \pm 1 second cycle time), and the equipment was operated for four more hours. This operation does not necessarily have to be continuous; however, no change or adjustments to the load or load restraints shall be permitted at any time during the test. The test load (specimen) shall not be removed from the apparatus, once positioned in place, until the test is completed or stopped.

PART 4

TEST RESULTS

A. RAIL IMPACT TEST

DATE: 21 JUNE 1990

TEST SPECIMEN: TRANSPORTABILITY TEST OF 2,000-POUND BOMBS
IN A SIDE OPENING COMMERCIAL CONTAINER

TEST TOFC NO: TTX 151044 LT.WT.: 73,400 pounds

CHASSIS NO: 5394 WT.: 4,000 pounds

SIDE OPENING MILVAN:USAF 0010598 WT.: 6,050 pounds

LADING & DUNNAGE WT.: 41,315 pounds

TOTAL SPECIMEN WT.: 124,765 pounds

BUFFER CAR (5 CARS) WT.: 250,000 pounds

IMPACT NO.	END STRUCK	VELOCITY	REMARKS
1	Forward	4.36	No Load Movement
2	Forward	6.28	No Load Movement
3	Forward	8.30	No Load Movement
4	Reverse	8.49	No Load Movement

ROAD TEST DATA

TEST NO. 2

DATE 27 June 1990

TEST SPECIMEN: TRANSPORTABILITY TEST OF 2,000 POUND BOMBS
IN A SIDE OPENING COMMERCIAL CONTAINER

PASS 1-A OVER FIRST SERIES OF TIES	0.11	MIN	5.16	MPH
PASS 1-B OVER SECOND SERIES OF TIES	0.10	MIN	5.68	MPH

REMARKS: No visible damage to the load of Side Opening Container.

PASS 2-A OVER FIRST SERIES OF TIES	0.10	MIN	5.68	MPH
PASS 2-B OVER SECOND SERIES OF TIES	0.12	MIN	4.73	MPH

REMARKS: No visible damage to the load of Side Opening Container.

30-MILE ROAD TRIP: No load movement or damage to the Side Opening Container.

PASS 3-A OVER FIRST SERIES OF TIES	0.11	MIN	5.16	MPH
PASS 3-B OVER SECOND SERIES OF TIES	0.09	MIN	6.31	MPH

REMARKS: No visible damage to the load of Side Opening Container.

PASS 4-A OVER FIRST SERIES OF TIES	0.10	MIN	5.68	MPH
PASS 4-B OVER SECOND SERIES OF TIES	0.11	MIN	5.16	MPH

REMARKS: No visible damage to the load of Side Opening Container.

WASHBOARD COURSE: No damage or load movement.

STS: No lateral load movement or damage to load, dunnage, or container.

PART 5

TIEDOWN PROCEDURES

APPROVED BY
BUREAU OF EXPLOSIVES

DATE _____

LOADING AND BRACING^① WITH WOODEN DUNNAGE IN SIDE OPENING COMMERCIAL CONTAINERS OF 2000-POUND BOMB, MK84 AND MODS, UNITIZED 2 BOMBS PER METAL PALLET, MK79 MOD 0

ITEM	INDEX	PAGE (S)
GENERAL NOTES AND MATERIAL SPECIFICATIONS-----		2
PALLET UNIT DETAIL-----		3
8-UNIT LOAD-----		4,5
DETAILS-----		6-8

① LOADING AND BRACING SPECIFICATIONS SET FORTH WITHIN THIS DRAWING ARE APPLICABLE TO LOADS THAT ARE TO BE SHIPPED BY TRAILER/CONTAINER-ON-FLAT-CAR (T/COFC) RAIL CARRIER SERVICE. THESE SPECIFICATIONS MAY ALSO BE USED FOR LOADS THAT ARE TO BE MOVED BY MOTOR OR WATER CARRIERS. SEE GENERAL NOTE "J" ON PAGE 2.

DO NOT SCALE

REVISIONS				REVISIONS	TH	CHECKER	TECHNICAL	ENGINEER
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GENERAL NOTES

- A. THIS DOCUMENT HAS BEEN PREPARED AND ISSUED IN ACCORDANCE WITH AR 740-1 AND AUGMENTS TH 743-200-1 (CHAPTER 5).
- B. THE SPECIFIED OUTLOADING PROCEDURES ARE APPLICABLE TO THE 2000 POUND BOMB, MK84 AND MOOS, UNITIZED 2 BOMBS PER METAL PALLET, MK-79 MOD 0. SUBSEQUENT REFERENCE TO PALLET UNIT HEREIN MEANS THE MK-79 METAL PALLET WITH MK-84 BOMBS INSTALLED. SEE PAGE 3 FOR THE DETAIL OF THE PALLET UNIT. CAUTION: REGARDLESS OF THE QUANTITY OF PALLETS TO BE SHIPPED, THE "MAXIMUM GROSS WEIGHT" OF THE CONTAINER INCLUDING LADING AND DUNNAGE MUST NOT BE EXCEEDED.
- C. THE LOAD AS SHOWN IS BASED ON A 6,050 POUND 20' LONG BY 8' WIDE BY 8'-6" HIGH SIDE OPENING INTERMODAL COMMERCIAL CONTAINER WITH INSIDE DIMENSIONS OF 19'-4" LONG BY 8' WIDE BY 8' HIGH. THE LOAD IS DESIGNED FOR TRAILER/CONTAINER-ON-FLAT-CAR (T/COFC) SHIPMENT. HOWEVER, THE LOAD AS DESIGNED CAN ALSO BE MOVED BY OTHER SURFACE MODES OF TRANSPORT. NOTICE: OTHER CONTAINERS OF THE SAME DESIGN CONFIGURATION CAN BE USED.
- D. WHEN LOADING THE DESIGNATED UNITS, THEY ARE TO BE POSITIONED SO AS TO ACHIEVE A TIGHT LOAD (TIGHT AGAINST THE END AND SIDE DUNNAGE ASSEMBLIES). LATERAL VOIDS WITHIN THE LOAD ARE TO BE HELD TO A MINIMUM. EXCESSIVE SLACK CAN BE ELIMINATED FROM A LOAD BY LAMINATING 6" WIDE PIECES OF APPROPRIATE THICKNESS(ES) TO THE DOOR PANEL GATES SO AS TO CONTACT THE DOORS WHEN THEY ARE CLOSED. NAIL EACH PIECE TO THE PANEL W/1 APPROPRIATELY SIZED NAIL EVERY 12".
- E. DUNNAGE LUMBER SPECIFIED IS OF NOMINAL SIZE. FOR EXAMPLE, 1" X 4" MATERIAL IS ACTUALLY 3/4" THICK BY 3-1/2" WIDE AND 2" X 6" MATERIAL IS ACTUALLY 1-1/2" THICK BY 5-1/2" WIDE.
- F. A STAGGERED NAILING PATTERN WILL BE USED WHENEVER POSSIBLE WHEN NAILS ARE DRIVEN INTO JOINTS OF DUNNAGE ASSEMBLIES OR WHEN LAMINATING DUNNAGE. ADDITIONALLY, THE NAILING PATTERN FOR AN UPPER PIECE OF LAMINATED DUNNAGE WILL BE ADJUSTED AS REQUIRED SO THAT A NAIL FOR THAT PIECE WILL NOT BE DRIVEN THROUGH ONTO OR RIGHT BESIDE A NAIL IN A LOWER PIECE.
- G. CAUTION: DO NOT NAIL DUNNAGE MATERIAL TO THE CONTAINER WALLS OR FLOOR. ALL NAILING WILL BE WITHIN THE DUNNAGE.
- H. PORTIONS OF THE CONTAINER DEPICTED WITHIN THIS DRAWING, SUCH AS THE SIDE DOORS, HAVE NOT BEEN SHOWN IN THE LOAD VIEWS FOR CLARITY PURPOSES.
- J. REQUIREMENTS CITED WITHIN THE BUREAU OF EXPLOSIVES PAMPHLET 66 APPLY WHEN THE SHIPMENT MOVES BY TRAILER/CONTAINER-ON-FLAT-CAR (T/COFC). SPECIAL T/COFC NOTES FOLLOW:
1. A LOADED CONTAINER MUST BE ON A CHASSIS EQUIPPED WITH TWO BOGIE ASSEMBLIES WHEN BEING MOVED IN TOFC SERVICE.
 2. THE LOAD LIMIT OF A T/COFC RAILCAR MUST NOT BE EXCEEDED, NOR WILL A CAR BE LOADED SO THAT THE TRUCK UNDER ONE END OF THE CAR CARRIES MORE THAN ONE-HALF OF THE LOAD LIMIT FOR THAT CAR.
- K. DURING INTRASTATE AND/OR INTERSTATE MOVES BY MOTOR CARRIER, A PROPER CHASSIS OR MODIFIED FLAT BED TRAILER MUST BE USED TO PRECLUDE VIOLATION OF ONE OR MORE "WEIGHT LAWS" APPLICABLE TO THE STATE OR STATES INVOLVED.
- L. CONVERSION TO EQUIVALENTS: DIMENSIONS WITHIN THIS DOCUMENT ARE EXPRESSED IN INCHES AND WEIGHTS ARE EXPRESSED IN POUNDS. WHEN NECESSARY, THE METRIC EQUIVALENTS MAY BE COMPUTED ON THE BASIS OF ONE INCH EQUALS 25.4MM AND ONE POUND EQUALS 0.454kg.

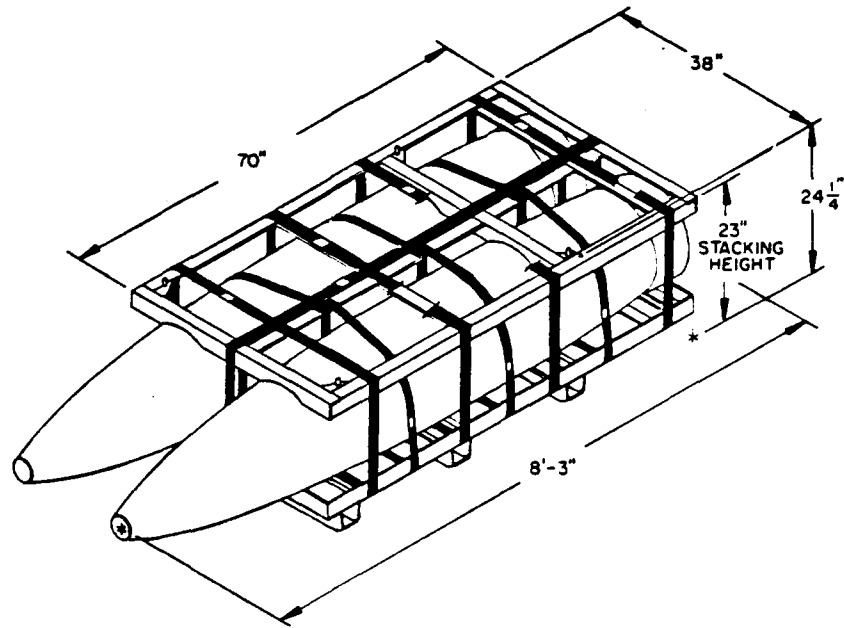
MATERIAL SPECIFICATIONS

LUMBER -----: SEE TH 743-200-1, DUNNAGE LUMBER; FED SPEC MM-L-751

NAILS -----: COMMON. FED SPEC FF-N-105.

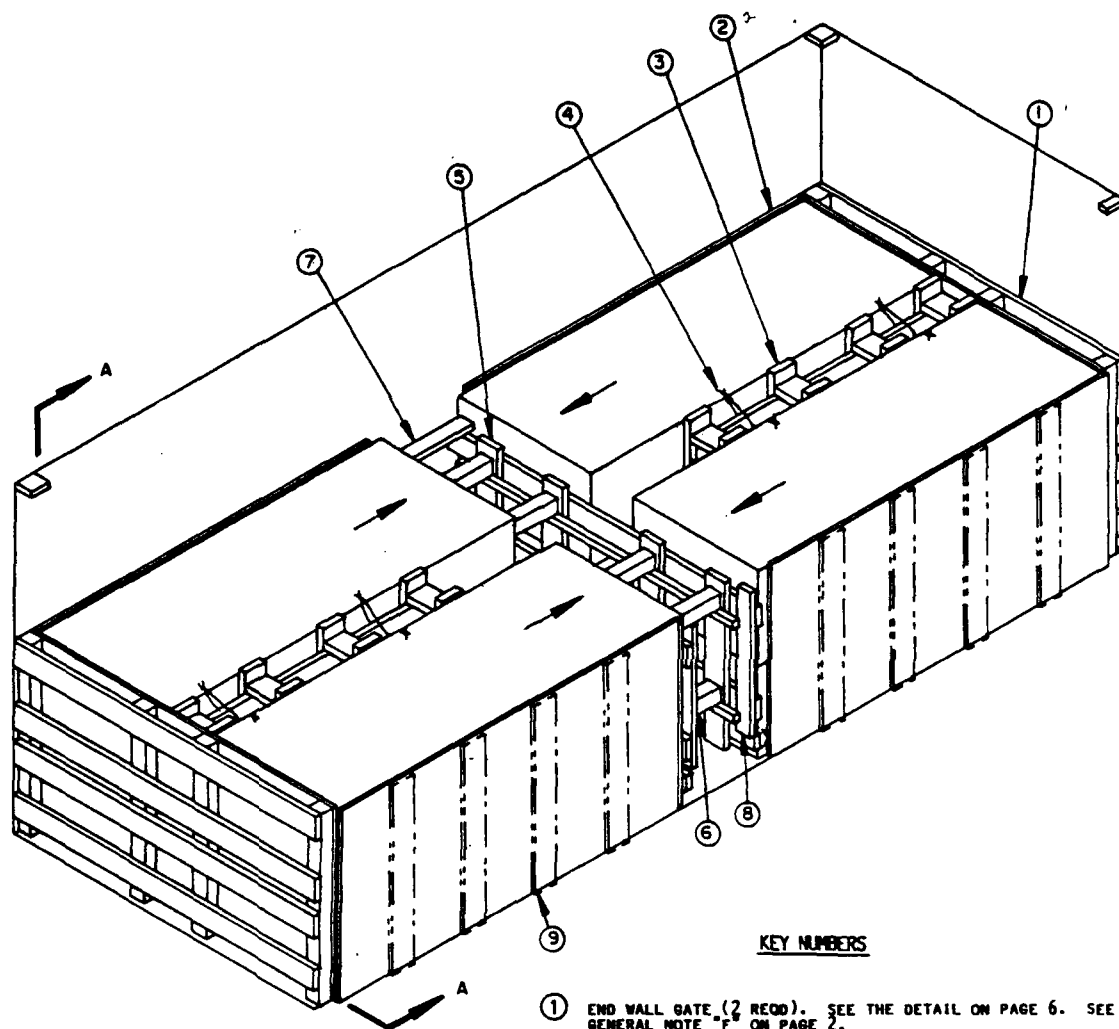
WIRE -----: ANNEALED, BLACK; FED SPEC QQ-W-461.

PLYWOOD -----: FED SPEC MM-P-530; GROUP B, CONSTRUCTION AND INDUSTRIAL PLYWOOD, INTERIOR WITH EXTERIOR GLUE, GRADE C-D. IF SPECIFIED GRADE IS NOT AVAILABLE, A BETTER INTERIOR OR EXTERIOR GRADE MAY BE SUBSTITUTED.



PALLET UNIT

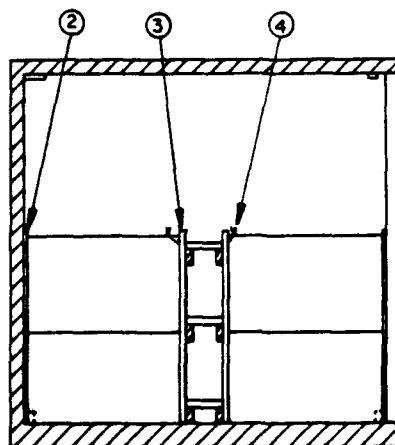
GROSS WEIGHT ----- 4,133 POUNDS (APPROX)
 CUBE----- 52.8 CUBIC FEET



ISOMETRIC VIEW

KEY NUMBERS

- ① END WALL GATE (2 REQD). SEE THE DETAIL ON PAGE 6. SEE GENERAL NOTE "F" ON PAGE 2.
- ② SIDE WALL/DOOR PANEL GATE (4 REQD: 2 RIGHT HAND, 2 LEFT HAND). SEE THE DETAIL ON PAGE 6.
- ③ CRIB FILL ASSEMBLY (2 REQD). SEE THE DETAIL ON PAGE 7. SEE GENERAL NOTE "F" ON PAGE 2.
- ④ TIE WIRE, NO. 8 GAGE BY LENGTH REQUIRED (REF: 42") (8 REQD). INSTALL TO TWICE ENCIRCLE A TOP TIE PIECE OF THE CRIB FILL ASSEMBLY AND A FRAME MEMBER OF THE PALLET UNIT TOP ASSEMBLY. TWIST ENDS TIGHT.
- ⑤ CENTER GATE (2 REQD). SEE THE DETAIL ON PAGE 7.
- ⑥ STRUT, 4" x 4" BY CUT-TO-FIT BETWEEN VERTICAL STRUT BEARING PIECES OF THE CENTER GATES, MARKED ⑤ (8 REQD). TOENAIL TO THE VERTICALS W/2-160 NAILS AT EACH END.
- ⑦ HORIZONTAL WALL PANEL STOP BLOCK, 2" x 4" x 27" (2 REQD). NAIL TO THE TOP EDGE OF THE UPPER AND LOWER LOAD BEARING PIECE OF THE CENTER GATES, MARKED ⑤, W/2-100 NAILS AT EACH END, SO AS TO CONTACT THE SIDE WALL OF THE CONTAINER.
- ⑧ VERTICAL DOOR PANEL STOP BLOCK, 2" x 4" x 36" (2 REQD). NAIL AT THE ENDS OF THE UPPER AND LOWER LOAD BEARING PIECES OF THE CENTER GATES, MARKED ⑤, W/3-100 NAILS AT EACH END, SO AS TO CONTACT THE DOOR OF THE CONTAINER.
- ⑨ FILL PIECES, 6" WIDE x 48" LONG (AS REQD). SEE GENERAL NOTE "D" ON PAGE 2.



PIECES MARKED ⑤ AND ⑧
DELETED FOR CLARITY

SECTION A-A

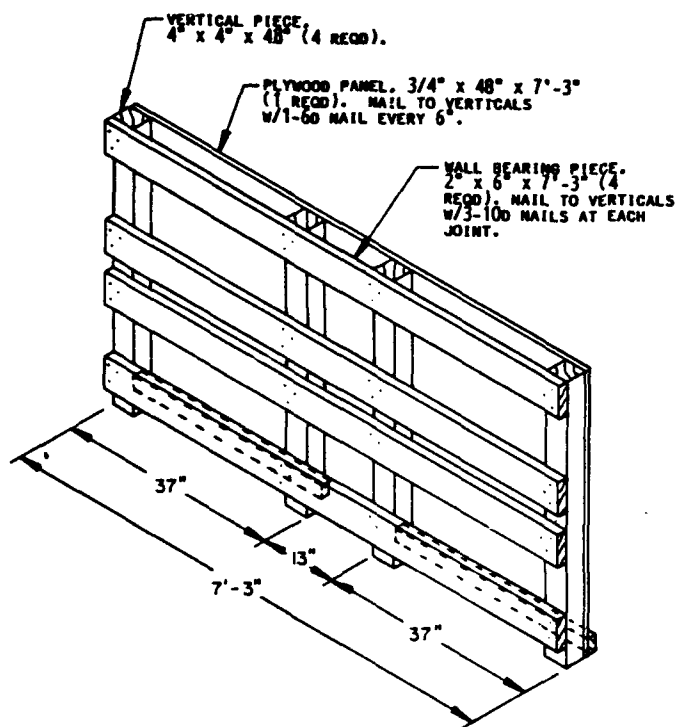
SPECIAL NOTES:

1. AN 8-UNIT, 2-LAYER LOAD IS SHOWN IN A SIDE OPENING INTERNATIONAL ISO COMMERCIAL FREIGHT CONTAINER.
2. A 4-UNIT, 1-LAYER LOAD CAN BE SHIPPED BY REDUCING THE HEIGHT OF THE DUNNAGE ASSEMBLIES AS SPECIFIED IN THE DETAILS.

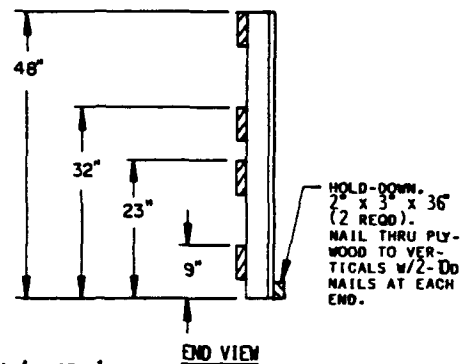
BILL OF MATERIAL		
LUMBER	LINEAR FEET	BOARD FEET
2" x 2"	28	10
2" x 3"	20	10
2" x 4"	103	69
2" x 6"	198	198
4" x 4"	44	59
NAILS	NO. REQD	POUNDS
6d (2")	88	1/2
10d (4")	532	8-1/2
10d (3-1/2")	32	3/4
PLYWOOD, 3/4"	192 SQ. FT.	396 LBS
WIRE, NO. 8 GAGE	28 L. FT.	3 LBS

LOAD AS SHOWN

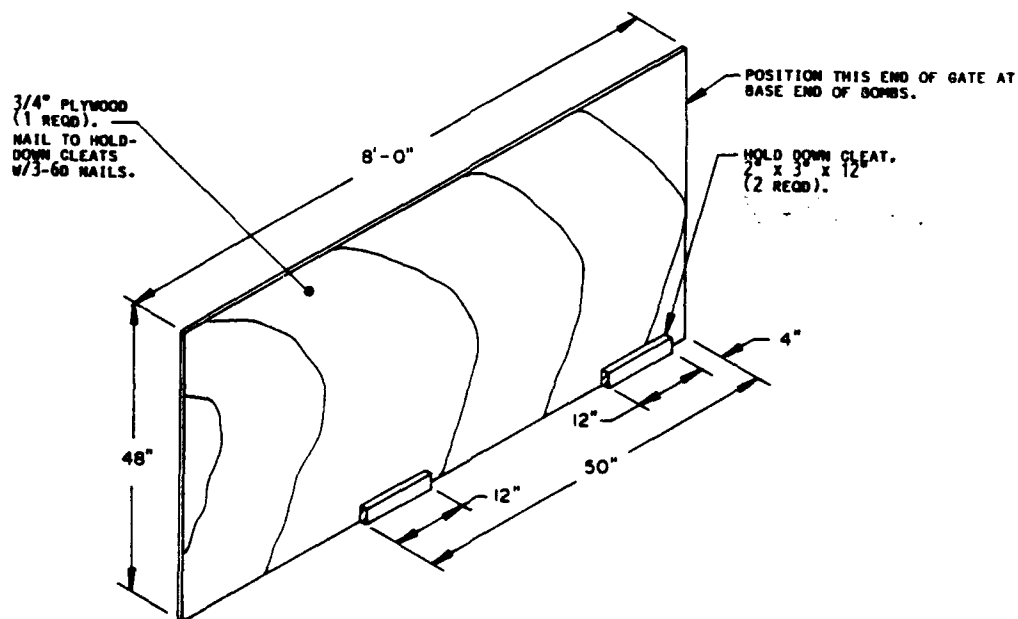
ITEM	QUANTITY	WEIGHT (APPROX)
PALLET UNIT	9	33.064 LBS
DUNNAGE		1.101 LBS
SIDE OPENING CONTAINER		6.050 LBS
TOTAL WEIGHT		40.215 LBS (APPROX)



END WALL GATE
SEE NOTE AT RIGHT

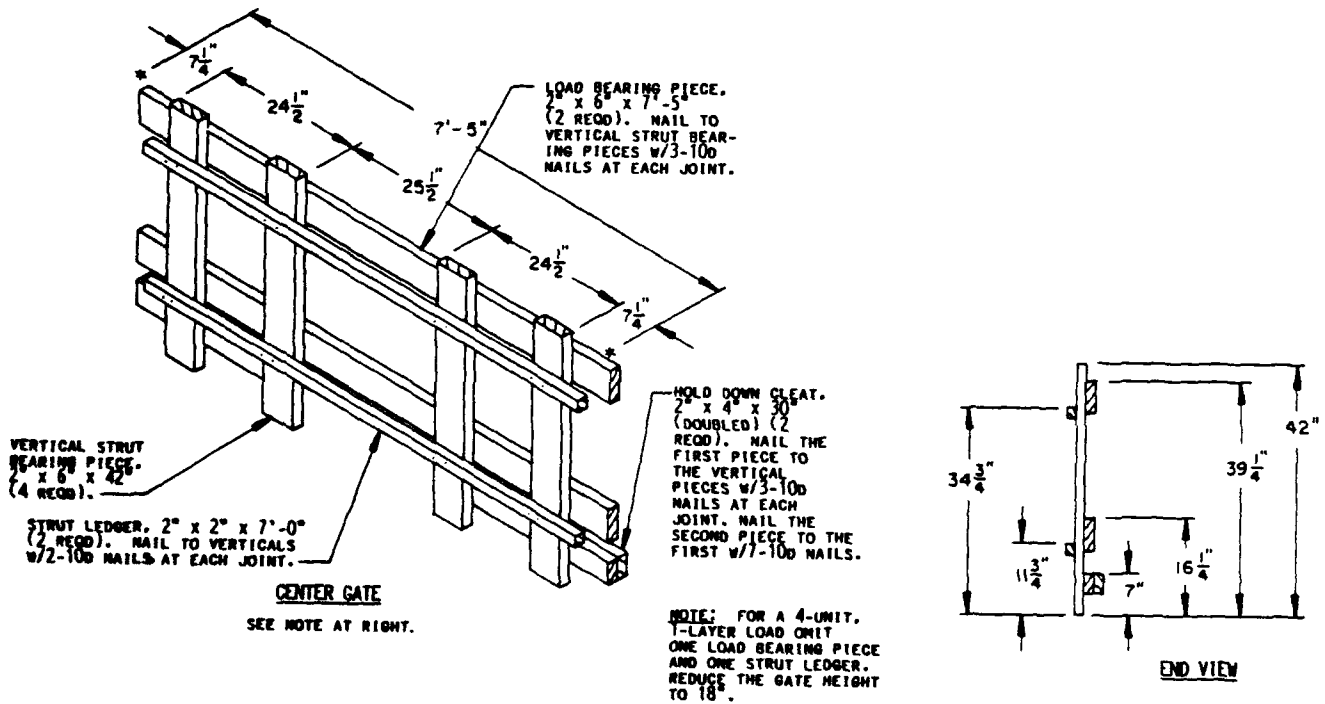
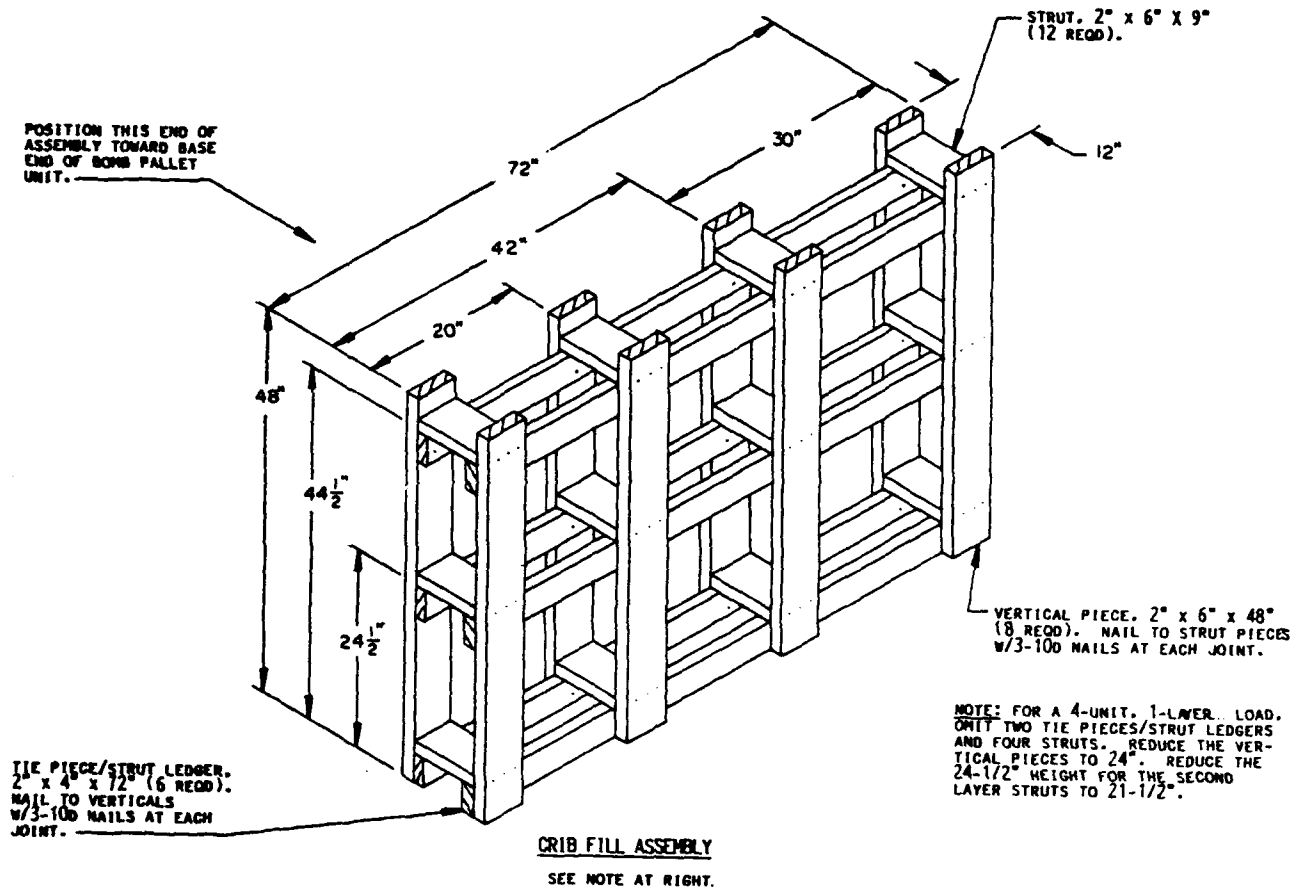


NOTE: FOR A 4-UNIT, 1-LAYER LOAD, REDUCE THE HEIGHT OF THE GATE TO 24". OMIT TWO WALL BEARING PIECES.



SIDE WALL/DOOR PANEL GATE
(2 REQD. RIGHT HAND)
(2 REQD. LEFT HAND)
SEE NOTE AT RIGHT

NOTE: FOR A 4-UNIT, 1-LAYER LOAD, REDUCE THE HEIGHT OF THE GATE TO 24".



PART 6

PHOTOGRAPHS



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-90-289-5177. This photo shows two commercial side opening containers after a rail impact. The open container was loaded with inert 2,000-pound bombs. The load was being inspected for excessive shifting and broken dunnage. None was found.



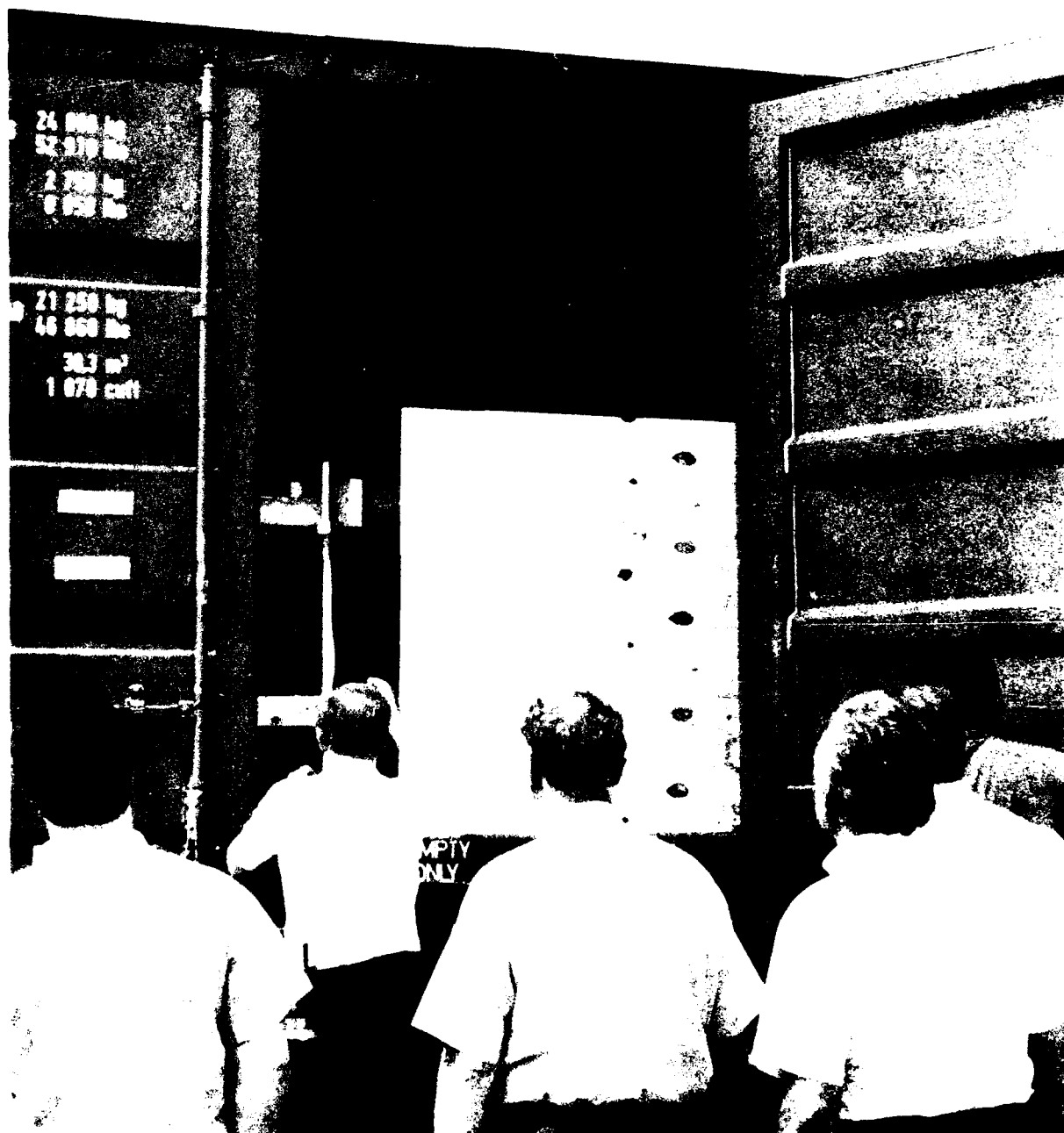
U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-90-289-5175. This photo shows the test engineer and BOE Senior Inspector viewing the 2,000-pound bomb dunnage after a rail impact.



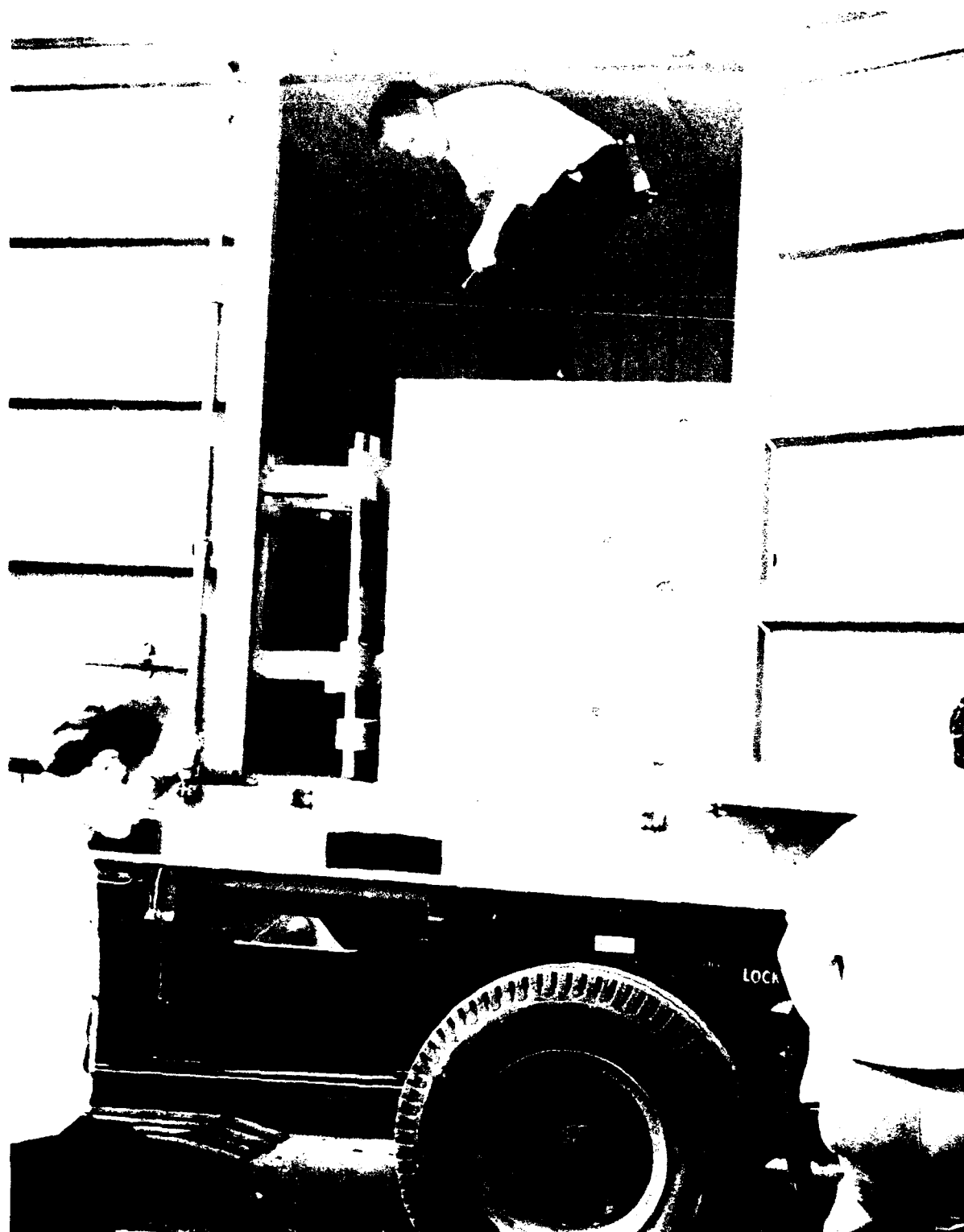
U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-90-289-5186. This photo shows the test load of 2,000-pound bombs being towed over the road hazard course. No damage or excessive load shift occurred during this test.



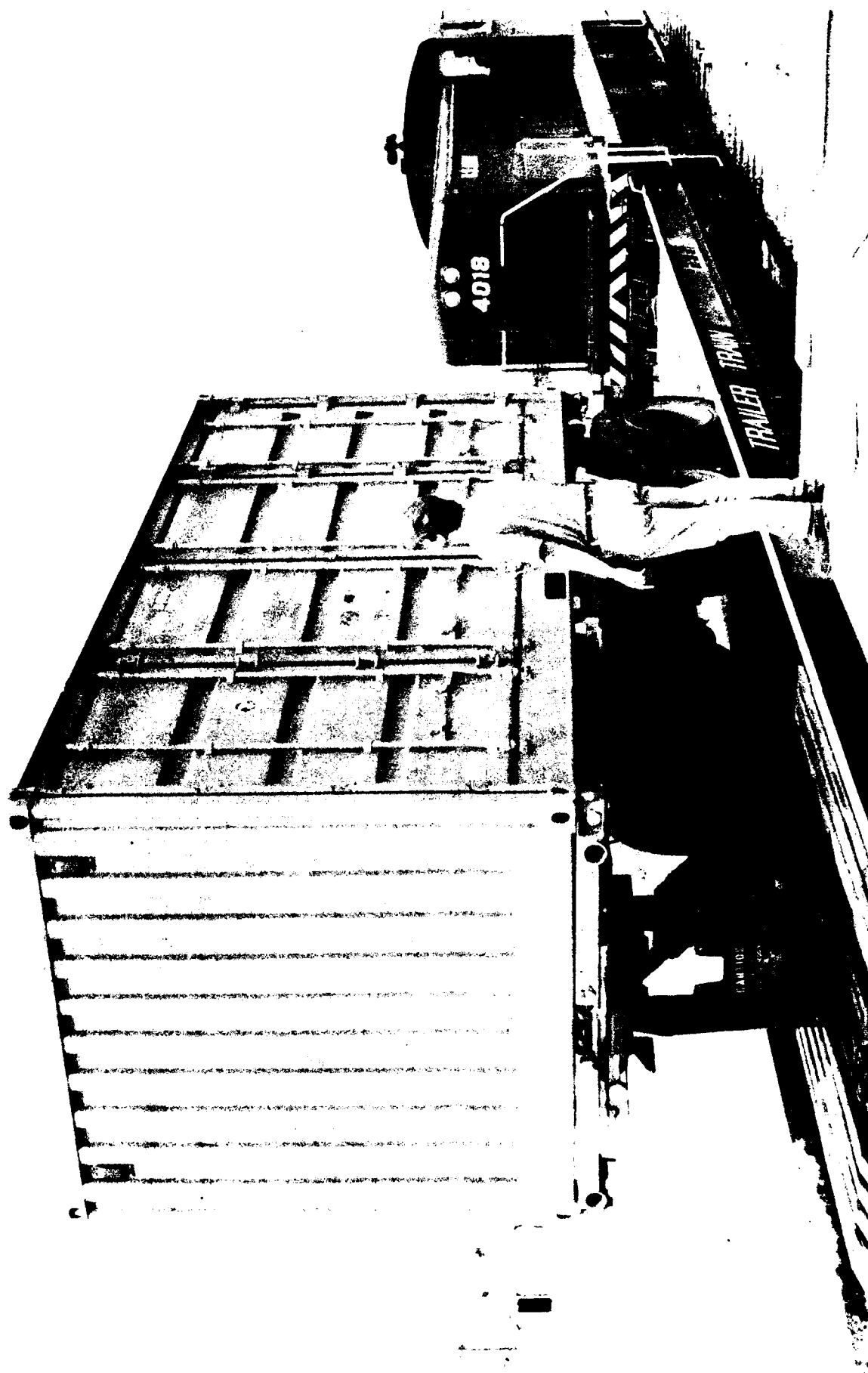
U.S. ARMY DEFENSE AMMUNITION CENTER AND
SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-90-289-5192. This photo shows the test engineer measuring the dunnage movement as a result of a rail impact.



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
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Photo No. AO317-SPN-90-289-5176. This photo shows the test engineer inspecting the test load in a side opening container loaded with inert 2,000-pound bombs. Upon completion of rail impact testing, load movement, was less than one inch.
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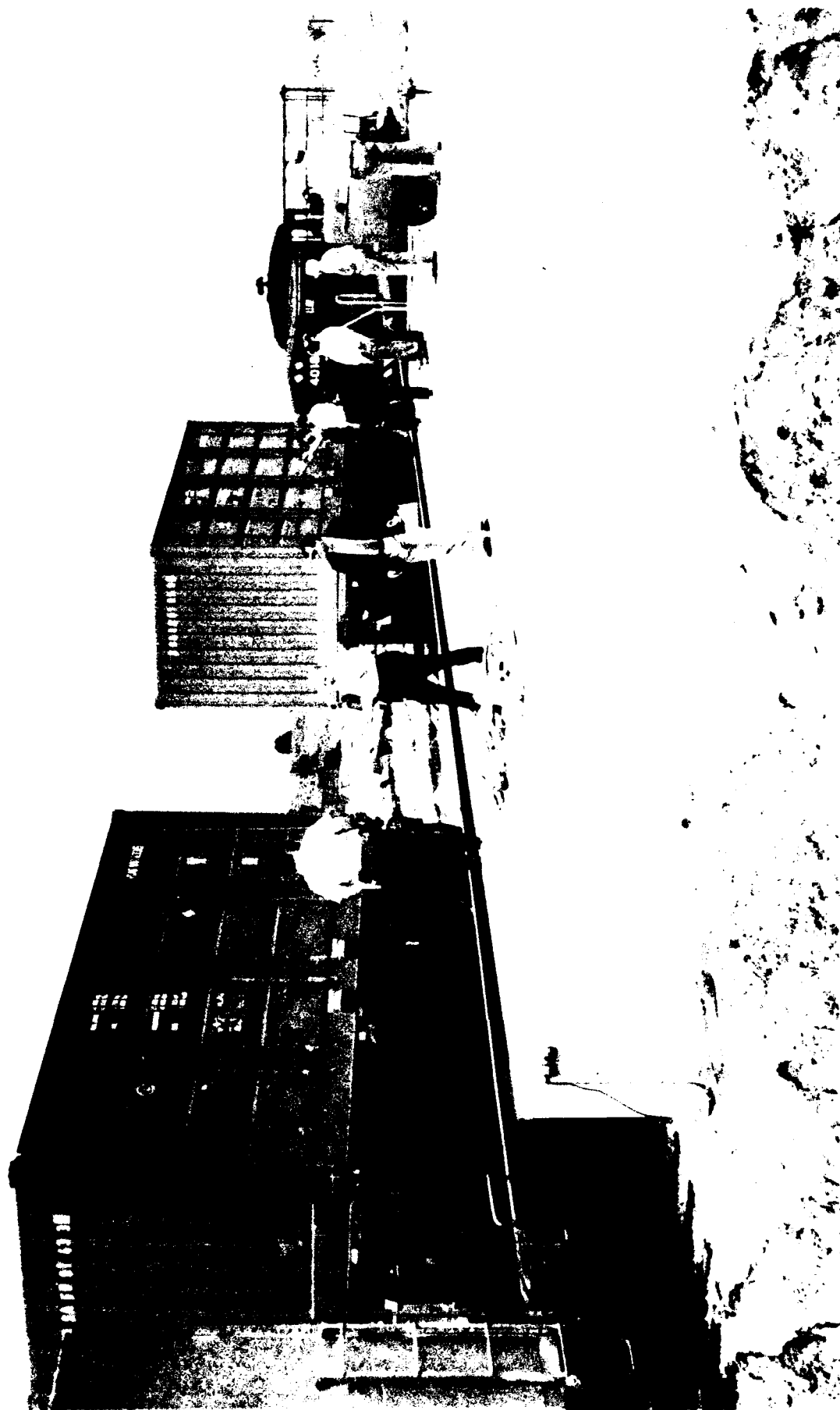
U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-90-289-5194. This photo shows the side opening container with an inert load of 2,000-pound bombs.



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-90-289-5193. This photo shows the side opening container with a door panel open. The load is about to be inspected after a rail impact.



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

Photo No. AO317-SPN-90-289-5196. This photo shows two side opening containers on a TOFC. The side opening container on the left contains an inert load of 30mm ammunition. The side opening container on the right contains eight pallets of inert 2,000-pound bombs.